



# Benefits and Costs of Advanced Motor Vehicle Technologies

1997 SAE GOVERNMENT/INDUSTRY  
MEETING

May 7, 1997

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# Introduction

- Analytic Purpose
- Modeling Process and Results
  - ◆ Vehicle Choice/Attributes
- Economic Consideration
  - ◆ Energy Security
  - ◆ Emissions
  - ◆ GPD and Jobs
- Benefit/Cost Results



# Analytic Purpose

- Benefit/Cost Evaluation of R&D Programs
  - ◆ The Three E's vs. Gov't Spending
- Strategic Planning
  - ◆ Scenario Analyses
    - ◆ Individual Technologies
    - ◆ Efficiency vs. Alternative Fuels

# Benefit and Cost Perspective

## ■ Societal

- ◆ Energy Security, Environmental, Economic

## ■ Consumer

- ◆ Perceived Value of Vehicle Attributes

## ■ Manufacturer

- ◆ Capital Investment and Payback

# Modeling Process

## INPUTS:

### Fuel Attributes:

- Price/Gallon of Gasoline Equivalent
- Gasoline
- Diesel
- Ethanol
- Methanol
- CNG
- LPG
- Electricity

### Light Duty Vehicle Attributes:

- Purchase Price
- Fuel Economy
- Range
- Maintenance Cost
- Luggage Space
- Acceleration
- Top Speed

### Heavy Duty Vehicle Attributes:

- Fuel Economy
- Fuel Price/Gallon of Gasoline Equivalent (CNG, Diesel)
- Expected Pay Back Period
- Discount Rate

### SCVS Model

- Calculates:
- Fuel Availability
  - Market Penetration for
    - Small Cars
    - Large Cars
    - Small Truck
    - Large Truck

### GREET Model

- Calculates for a full fuel cycle  
Grams per mile emissions for:
- HC
  - CO
  - NOx
  - PM 10
  - SOx

### HDMP Model

- Calculates Market Penetration For:
- Class 3-6 Centrally Refueled
  - Class 3-6 Non-Centrally Refueled
  - Class 7-8 Over 50k miles/yr
  - Class 7-8 Under 50k miles/yr

### ESM

- Calculates:
- GDP Effects
  - Jobs

### IMPACTT Model

- Calculates:
- Vehicle Sales
  - Vehicle Stocks
  - Vehicle Miles Traveled
  - Alternative Fuel Use
  - Petroleum Displaced
  - Emissions Reductions

### Other Calculations

- GHG Reductions
- Energy Cost Reductions
- Total Incremental Vehicle Cost
- Capital Investment Requirements

## KEY:

SCVS - Size Class Vehicle Sales Model

GREET - Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model

IMPACTT - Integrated Market Penetration and Anticipated Cost of Transportation Technologies Model

HDMP - Heavy Duty Market Penetration Model

ESM - Employment Spreadsheet Model

# Survey Results: Unit Equivalent Values per \$1000

	Small Car	Passenger Truck
MPG	5.4	2.0
Range (miles)	56	28
Acceleration (0 to 30 mph)	-1.3	-0.64
Top Speed	18	NA
Luggage Space	14%	3%

# Advanced Vehicle Price

## Passenger Truck

	Diesel	Electric	Hybrid	Fuel Cell
Year of Intro.	2003	1999	2011	2013
Year of Matur.	2008	2015	2015	2013
Intro. Price	1.15	2.00	1.25	1.30
Matur. Price	1.10	1.15	1.20	1.30

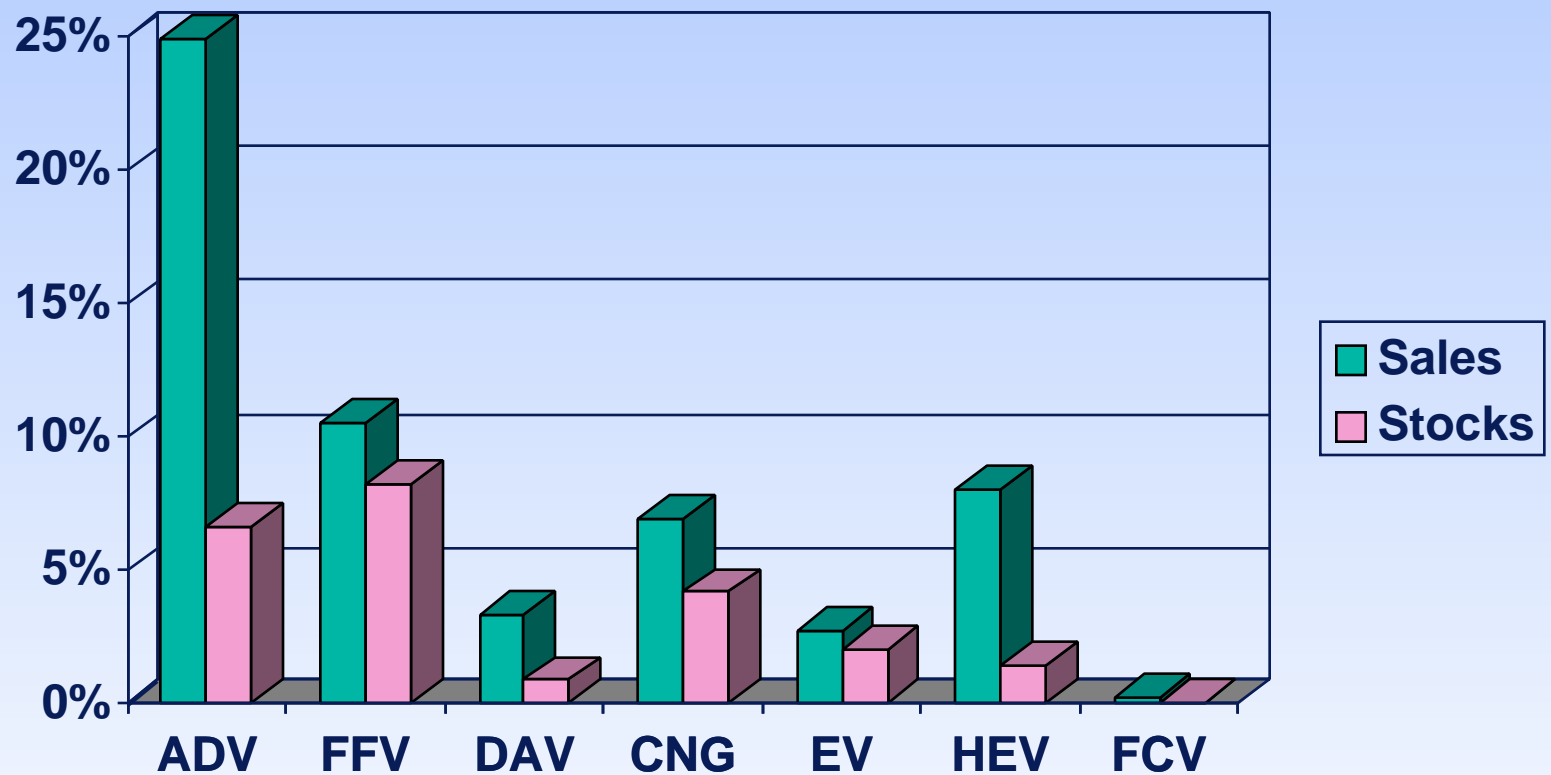
# Advanced Vehicle MPG

## Passenger Truck

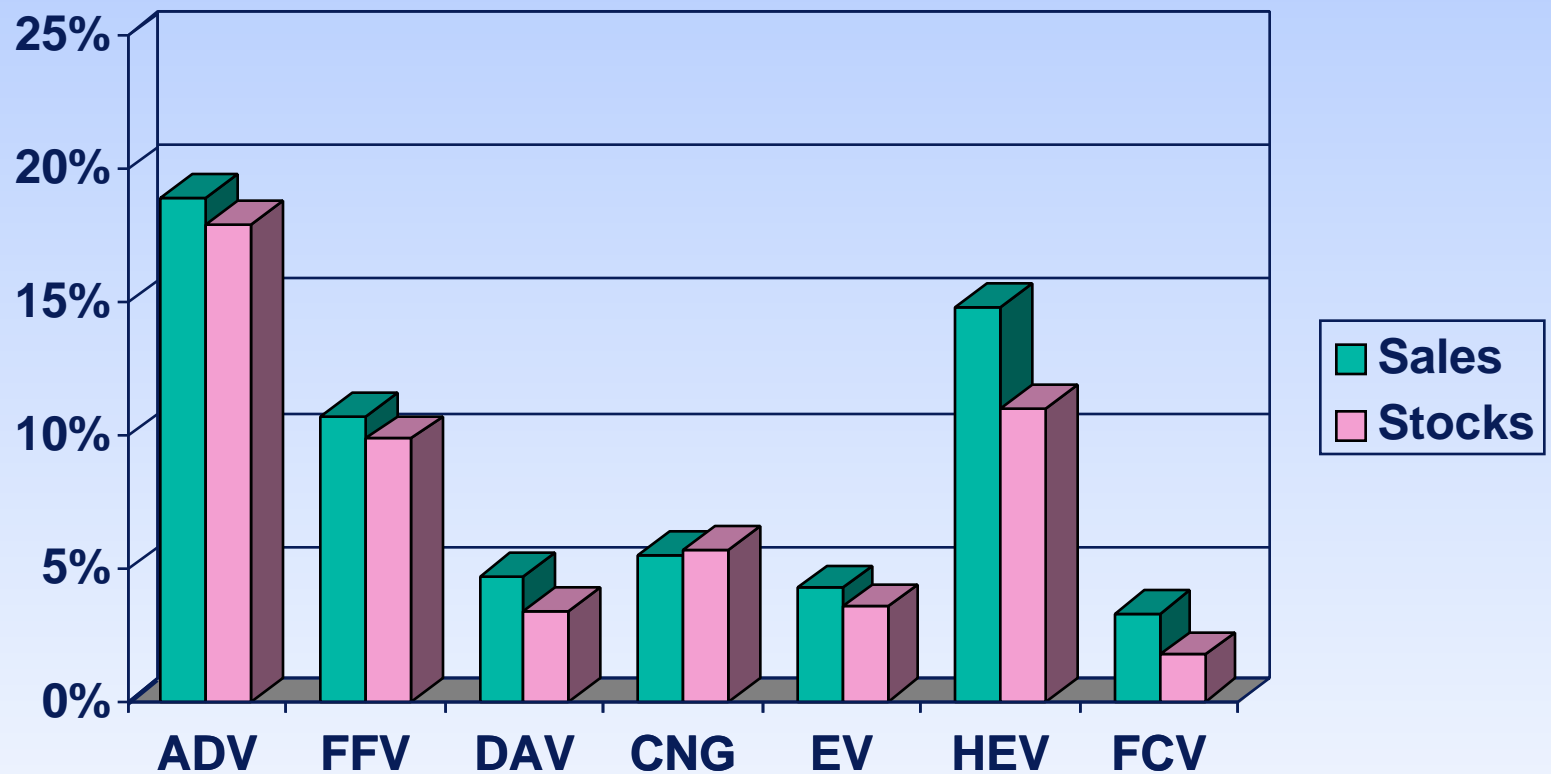
	Diesel	Electric	Hybrid	Fuel Cell
Year of Intro.	2003	1999	2011	2013
Year of Matur.	2008	2015	2015	2013
Intro. MPG	1.15	4.0	1.4	2.5
Matur. MPG	1.25	4.0	2.1	2.5



# 2010 Light Duty Vehicle Market Penetration



# 2020 Light Duty Vehicle Market Penetration



# Primary Oil Displaced

<i>million barrels per day</i>	2010	2020
Advanced Diesel	0.03	0.11
Electric	0.11	0.18
Hybrid	0.05	0.38
Fuel Cell	0.00	0.09
CNG	0.42	0.45
Biofuels	0.36	0.65
Heavy Vehicles	0.09	0.22
<i>Total</i>	<i>1.07</i>	<i>2.08</i>

# Carbon Emission Reductions

<i>mmtons CO<sup>2</sup> Carbon Equivalents</i>	2010	2020
Advanced Diesel	1.3	4.0
Electric	0.0	0.0
Hybrid	2.1	15.2
Fuel Cell	0.0	2.9
CNG	4.4	4.7
Biofuels	14.5	26.0
Heavy Vehicles	3.4	8.5
<i>Total</i>	<i>25.7</i>	<i>61.3</i>



# Criteria Emission Reductions

<i>thousand tonnes</i>	2010	2020
NO <sub>x</sub>	65.0	30.8
CO	2849.0	8010.0
HC	208.7	525.7



# Criteria Values

Energy Security	\$4 per barrel
Carbon Monoxide	\$300 per tonne
Hydrocarbons	\$3,050 per tonne
Nitrogen Oxides	\$2,750 per tonne
Carbon Dioxide	\$15 per ton

# Economic Spreadsheet Model

- Tracks Cash Flows Related to Penetration of Advanced Technologies
- Flows Include:
  - ◆ Incremental Vehicle Costs
  - ◆ Changes in “Baseline” Consumer Spending
  - ◆ Alternative Fuel Costs
- Cash Flows Are Multiplied by Job and GDP Multipliers

# ESM: Job and GDP Multipliers

	Job Multipliers (Jobs per \$M)	GDP Multipliers (\$M GPD per \$M)
Agriculture	26.86	2.12
Refining	7.14	2.02
Oil and Gas Extraction	7.02	1.34
Gas Utility	7.41	1.99
Electric Utility	9.54	1.78
Motor Vehicles	13.70	2.19
Household	16.80	1.47
Wholesale Trade	20.43	1.47



# Employment Impacts

<i>Thousands of Jobs</i>	2010	2020
Advanced Diesel	4.0	21.6
Electric	10.6	26.5
Hybrid	(11.3)	43.3
Fuel Cell	(1.1)	(2.8)
CNG	32.9	29.0
Biofuels	27.8	74.8
Heavy Vehicles	(11.5)	21.9
<i>Total</i>	<i>51.4</i>	<i>214.3</i>

# GDP Impacts

<i>Million 1994 \$</i>	2010	2020
Advanced Diesel	726	601
Electric	2,404	2,343
Hybrid	4,400	7,637
Fuel Cell	233	2,723
CNG	1,798	3,935
Biofuels	3,207	3,615
Heavy Vehicles	4,236	14,428
<i>Total</i>	<i>17,004</i>	<i>35,282</i>

# Cumulative Benefits and Costs

<i>Billion 1994 \$</i>	2010	2020
Budget Costs	2	2
Benefits	48.9	349.2
<i>Energy Savings</i>	31.4	202.9
<i>Oil Security</i>	1.2	4.2
<i>Fuel Price Changes</i>	7.2	12.9
<i>Pollution Reduction</i>	11.2	70.4
<i>Incremental Costs</i>	(122.4)	(377.8)
<i>GDP Benefits</i>	120.3	436.7
Benefit to Cost Ratio	24.5	174.6

# Closing Remarks

- Dynamic Modeling Process
  - ◆ New Vehicle Choice Model
  - ◆ Updated Total Fuel Cycle and Emissions
- Peer Reviewed
- Technology Attributes Reflect Program Goals